# CURRENT-RATING TABLES FOR BUNDLED AIRCRAFT CABLES CARRYING CONTINUOUS D-C CURRENTS

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ABSTRACT

A tabular method for rating bundled cables carrying continuous d-c currents has been devised. The basic thermal assumptions required were taken from previous study of the current and temperature rise in aircraft cables (NRL Reports 3587, 3936, and 4142).

The tabular method can be applied to any given set of cables, e.g., MIL-W-5086, MIL-W-7072, etc., for a wide range of bundle installation and environmental conditions. The method of computing and compiling the necessary data is explained. An example of one pair of cable-rating and -selection tables is given along with illustrations which show their use in finding the correct cable sizes when the currents are given and in finding the currents when the bundled cables are given.

The tables are applied to a number of bundles and the results compared with MIL-W-5088A ratings. The results show that the latter may seriously underload or overload cables in bundles.
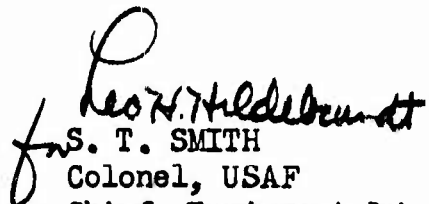
Application of the proposed rating methods will lead to the lowest cable weight consistent with the safety of the aircraft.

It is recommended that the tabular method be applied to several aircraft to gain needed information and experience before incorporation of the tables into the cable-rating specification is effected.

PUBLICATION REVIEW

This document has been reviewed and approved.

FOR THE COMMANDER:

S. T. SMITH
Colonel, USAF
Chief, Equipment Laboratory

FOREWORD

This report was prepared by the Electrical
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PROBLEM STATUS

This report is an interim report and completes
one phase of the work on the current rating of aircraft
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An investigation of the significance of the skin and
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AUTHORIZATION

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CURRENT-RATING TABLES FOR BUNDLED AIRCRAFT CABLES CARRYING CONTINUOUS D-C CURRENTS

I. INTRODUCTION

NRL Report 4142 presented a basis for rating aircraft cables in bundles carrying continuous d-c currents and described a graphical method for matching cable sizes to thermally allowable current ratings. The purpose of this report is to facilitate the application of those ratings. Specifically, it will be shown how cable-selection and -rating tables may be prepared so that the procedure for choosing the correct cable sizes or for assigning allowable currents for the bundled condition becomes extremely simple.

II. CONDITIONS OF THE PROBLEM

The current rating of cables depends on the thermal conditions which are assumed. For the case of bundled cables, there are three groups of conditions or factors affecting heat transfer which must be specified for a complete statement of the problem. (1) The properties of the set of cables from which individual cable sizes are to be selected. In particular, conductor radius and resistivity, insulation thickness, thermal conductivity, emissivity, and limiting temperature have to be prescribed for the set of cables. (2) The properties of the bundle. These are the interval of tie or support, shape of bundle, number of cables which may carry current simultaneously, and the allocation of power dissipation density[†] among the cables loaded simultaneously. The last named factor will be discussed in the next section. (3) Environmental conditions. These include: (a) location of the bundle, i.e., whether in air, conduit, trough, or jacket, (b) type of convection, i.e., natural or forced, and (c) temperatures of the air, adjacent equipment and surrounding walls.

[†]Power dissipation density (PD) is defined as the heat dissipated (I^2R) by a unit length of cable divided by its cross-section area of insulation and conductor.

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III. A BASIS FOR RATING CABLES IN BUNDLES[†]

The rate at which heat is dissipated by any bundle of aircraft cables which are subject to given thermal limitations is primarily a function of the cross-section area of the insulation and conductor of the loaded cables.[††] It is assumed here that the PD of all cables loaded simultaneously is the same. This assumption is made for simplicity since there are many distinct sets of currents (and corresponding sets of PD values) for a given group of cables which produce the same maximum conductor temperature. It is, moreover, the simplest premise for which a system of compatible current ratings can be devised. In addition, a PD for the bundle can be defined which is equal to the PD of each of the individual cables; thus,

$$PD \text{ for the bundle} = \frac{\text{Sum of } I^2 R \text{ of the individual cables}}{\text{Sum of cross-section areas of the indiv. cables}}$$

$$= \frac{I^2 R \text{ of any one cable}}{\text{Cross-section area of the corresponding cable}}$$

Experiment shows that this assumption is sufficient to insure the result that any bundle of aircraft cables will dissipate heat at a rate as least as high as that for a bundle of the same cross-section area and composed entirely of cables of the smallest permissible size.

It can now be seen that the curve of PD versus cross-section area for uniform bundles[†††] of the smallest permissible cable size together with the assumption of a uniform PD for the cables loaded simultaneously provide a sound conservative basis for the heat dissipation in all bundles for any given set of environmental conditions. The curve will be referred to as the "R" curve. R curves may be obtained experimentally or may be calculated as described in Appendix I of reference (1). Figure 1 is an example of an R curve obtained from

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[†] See reference (1) for a more detailed discussion.

[††] Unless otherwise noted, the word "area" will mean cross-section area of conductor and insulation.

[†††]Uniform bundles are bundles composed of cables of a single size.

measurements on bundles composed of 1, 3, 7, 19, 37, and 169 AN-18 cables under conditions described in section IV for Tables 1 and 2.

In the preceding discussion, it has been assumed that all cables in a bundle were carrying current simultaneously. In many bundles only a fraction of the total number of cables which are physically bound together carry current at the same time, and the question arises, how does our thermal basis apply. In brief, the answer is that we treat the fraction of cables, i.e., the group loaded simultaneously, as a distinct bundle having its own bundle PD and bundle area. The unloaded cables may aid or impede slightly the flow of heat from the loaded group. For compact bundles bound by ties or supports at intervals of six inches or less these slight effects may be safely neglected. In the remainder of the report, the term "bundle" will refer to the group of cables loaded simultaneously; thus, "bundle PD" and "bundle area" describe the PD and the area of the group of cables loaded simultaneously.

IV. CABLE-SELECTION AND -RATING TABLES

The purpose of this section is to show how cable-selection and -rating tables may be constructed for any given set of conditions. The tables are designed so that the two criteria of the preceding section are satisfied, i.e., (1) the PD for all cables in the bundle is the same, and (2) the point determined by the bundle area and bundle PD lies on the applicable R curve.

In outline, the tabular method of selecting cables consists of four steps. An explanation of these steps will follow their statement.

(1) A nominal cable area, NA, corresponding to one arbitrarily assumed cable PD, is found for each current of the bundle.

(2) A nominal bundle area, TNA, is obtained by adding the NA values of step (1). In accordance with our definition, the bundle PD for this TNA is numerically equal to the assumed cable PD.

(3) The nominal bundle area and the assumed PD are used to determine the required bundle PD, $(PD)_R$ and area, a_R.

(4) The cable size for each of the given currents is selected corresponding to $(PD)_R$ and a_R of step (3).

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In order to obtain the NA values of step (1), a table is needed which gives a nominal cable area for each value of current for the range required (e.g., from 1 to 1000 amperes) for a common PD. The relation between NA and current for fixed PD can be derived as follows. It will be recalled that the PD of a cable for a given current I is defined by

$$PD = \frac{I^2 R_n}{a_n} \tag{1}$$

where R_n is the conductor resistance per unit length at the maximum allowable temperature and a_n is the cross-section area of insulation and conductor. We now introduce an experimental result which is needed not only for this step but for the remaining ones as well. If PD is plotted as a function of area for aircraft cables (from size AN-20 to AN-1/0) for a fixed current, it is found that PD may be well approximated by a simple power function of cable area, i.e.,

$$PD = (PD)_o \left(\frac{a}{a_o}\right)^m \tag{2}$$

where $(PD)_o$ is the PD corresponding to an arbitrary reference cable whose cross-section area is a_o and conductor resistance is R_o.

$$(PD)_o = \frac{I^2 R_o}{a_o} \tag{3}$$

where I = current. Combining (2) and (3) gives

$$PD = I^2 \left(\frac{R_o}{a_o^{(m+1)}}\right) a^m \tag{4}$$

An example of PD as a function of area is shown in Figure 2 on a logarithmic scale. This particular curve is plotted for one ampere. Equation (4) may be rewritten

$$a = \left(\frac{PD \, a_o^{m+1}}{R_o}\right)^{1/m} I^{-2/m} \tag{5}$$

which is the desired relation for tabulating NA and current.

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The second step outlined above is obvious and we proceed to step (3). The point determined by step (2), having coordinates TNA and the assumed PD, will not, in general, satisfy our second criteria, i.e., it will not lie on the applicable R curve. However, this point is related to the desired point on the R curve. To demonstrate this fact, we need to introduce a definition and a result derived from equation (4). A plot of PD versus area for a fixed value of current, such as given by Figure 2, will be called a current line. Equation (4) may be used to plot a family of current lines, i.e., one line for each value of current. These current lines are significant because the point determined by step (2) for a given set of currents will be located on one of these lines. Moreover, had we started with a different assumed value of PD in step (1), determined new NA values for the given set of currents, and a corresponding TNA, it can be shown that the new point would lie on the same current line as the first point. (The proof of this statement is given in the Appendix.) Since the PD values assumed are wholly arbitrary, it follows that all possible points which can be determined for a given set of currents - including the desired point on the R curve - must lie on the same current line. Since the point determined by step (2) and the desired point on the R curve lie on the same current line, they must be related by an equation of the form of equation (2).

$$PD = (PD)_R \left(\frac{a}{a_R}\right)^m \tag{6}$$

The subscript "R" refers to the values on the R curve; the symbols without subscript refer to the values obtained in step (2).

After the actual bundle area and PD have been determined, the individual cable sizes remain to be selected. The currents which correspond to a given cable size for a predetermined PD can be calculated and tabulated with equation (4).

For clarity and convenience, the procedure for setting up the tables will be specified. The proposed method requires two kinds of tables. Type A tables list one nominal cable area, NA, corresponding to each current of a set of current values for a common value of PD. Type B tables list the actual area of each point on the R curve, AA, and a corresponding nominal bundle area, TNA, for the fixed PD value used in Type A tables. In addition, Type B tables give the maximum allowable current for each cable size for each AA.

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Step 1. To obtain the exponent m needed in subsequent steps, plot PD as a function of cable cross-section area, a, for the given set of cables and for a fixed current on a logarithmic scale.

$$PD = \frac{I^2 R_n}{a_n} \tag{7}$$

The conductor resistance, R_n for each cable is taken at the maximum allowable temperature. a_n is the corresponding cross-section area of conductor and insulation. For convenience, the current may be taken as one ampere. The slope of the mean straight line through the points plotted is the desired exponent.

Step 2. Calculate the nominal area, NA, for each current, I_1 within the range needed and for a fixed PD with the equation

$$a_1 = \left(\frac{R_o}{(PD)_1 \, a_o^{1+m}} \right)^{-1/m} I_1^{-2/m} \tag{8}$$

$(PD)_1$ may be taken as 1, R_o and a_o, corresponding to any one cable, may be obtained from data required for Step 1.

Step 3. Determine by experiment or calculate the R curve corresponding to the given set of cables, bundle properties and environmental conditions.[+]

Step 4. Calculate each total nominal area, TNA, for the fixed $(PD)_1$ of Step 2, which corresponds to each $(PD)_R$ and total actual area, AA, on the R curve by

$$a_1 = a_R \left(\frac{(PD)_R}{(PD)_1} \right)^{-1/m} \tag{9}$$

[+] See reference 1.

In this equation, $a_R = AA$, and $a_1 = TNA$.

Step 5. Calculate the allowable current for every cable size for each of the series of $(PD)_R$ values employed in Step 4 with

$$I = a^{-m/2} \left(\frac{(PD)_R a_o^{1+m}}{R_o} \right)^{1/2} \tag{10}$$

Table 1 is an example of a type A table valid for the following conditions:

1. Cables whose dimensions and conductor resistance fall within limits given by MIL-W-5086 for sizes AN-22 and larger will be taken as standard. The thermal conductivity and emissivity of the insulation will be taken to be 0.0030 watt inch^{-1} °C^{-1} and 0.90, respectively.

2. Bundle size is limited to a maximum cross-section area (insulation and conductor) of approximately four square inches. This area corresponds roughly to a bundle of 20 AN-1/0 or to a bundle of 450 AN-18 cables.

3. Each bundle should be a compact group, roughly circular in cross section and bound by ties or supports at intervals of six inches or less.

4. No limit is placed on the number of cables which may carry current simultaneously.

5. Bundles are located in free air; heat is transmitted from the bundle surface by natural convection and radiation only.

6. The temperature rise of the hottest conductor in each bundle is 40°C in an ambient air temperature up to 60°C at sea level. It is assumed that all surrounding surfaces are the same temperature as the air.

7. It is assumed that the power dissipation density for all cables loaded simultaneously is the same.

Table 2 is the type B table corresponding to Table 1.

V.   PROCEDURE FOR USING THE PROPOSED NRL TABLES
       FOR SELECTING THE PROPER CABLE SIZES

Step 1. Find the nominal area (NA) for each current from Table 1.
         Table 1 gives one nominal area for each current value from
         1 to 1000 amperes.

Step 2. Obtain, by addition, the total nominal area (TNA) for all
         currents which flow simultaneously in the bundle.

Step 3. Select the cable size for each current from Table 2 for the
         TNA obtained in Step 2. Table 2 shows the maximum allowable
         current for each cable size (from AN-22 to AN-2/0) for each
         total nominal area (from .08 to 5.2).

VI.   ILLUSTRATION OF PROCEDURE FOR SELECTING CABLE
       SIZES

       Consider a bundle in which the following currents are to flow
simultaneously:

                    20 loads of 4 amperes each
                    10 loads of 12 amperes each
                     5 loads of 42 amperes each
                     2 loads of 120 amperes each
                     1 load of 150 amperes

Step 1. From Table 1 choose the NA (nominal area) for each current.
         For our example we have:

                      4 amperes - .0240
                     12 amperes - .0622
                     42 amperes - .184
                    120 amperes - .458
                    150 amperes - .554

Step 2. Find, by addition, the TNA (total nominal area).

         20 loads of 4 amperes each: 20 x .0240 = .480
         10 loads of 12 amperes each: 10 x .0622 = .622
          5 loads of 42 amperes each: 5 x .184   = .920
          2 loads of 120 amperes each: 2 x .458   = .916
          1 load of 150 amperes: = .554
                                        TNA   = 3.492

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Step 3. In Table 2, locate the TNA of Step 2 (or next larger tabulated TNA) and select the cable sizes from this row. In our example, cable sizes are selected from the TNA row 3.6. We find that the following sizes are required:

each 4 ampere load	AN-16
each 12 ampere load	AN-10
each 42 ampere load	AN-4
each 120 ampere load	AN-2/0
each 150 ampere load	AN-2/0

VII. PROCEDURE FOR USING PROPOSED NRL TABLES FOR DETERMINING CONTINUOUS CURRENT CAPACITY OF A GIVEN BUNDLE

Step 1. Obtain from Table 2 the individual cable areas. Individual cable area appears at the top of Table 2 under each AN cable size.

Step 2. Find, by addition, the total actual cable area (AA) of cables which are to carry current simultaneously.

Step 3. Select the current capacity for each cable size corresponding to the total actual cable area (AA) obtained in Step 2 for the nearest larger tabulated value. Table 2 shows the maximum allowable current for each cable size for each AA from .0076 to 2.80.

VIII. ILLUSTRATION OF PROCEDURE FOR DETERMINING MAXIMUM ALLOWABLE CONTINUOUS CURRENTS

Consider a bundle in which the following sizes are to carry current simultaneously:

10 AN-18
5 AN-8
2 AN-1/0

Step 1. Obtain the individual cable areas from Table 2.

<div align="center">

each AN-18	.00844
each AN-8	.0467
each AN-1/0	.1976

</div>

Step 2. Find, by addition, the total actual area of all cables in the bundle which carry current simultaneously.

<div align="center">

10 AN-18	10 x .00844	.0844
5 AN-8	5 x .0467	.2335
2 AN-1/0	2 x .1976	.3952
	AA =	.7131

</div>

Step 3. Select the current rating corresponding to the AA value obtained in Step 2. For our example, we find that

<div align="center">

each AN-18 may carry 3.8 amperes
each AN-8 may carry 27.7 amperes
each AN-1/0 may carry 147 amperes

</div>

We could properly have interpolated between the AA values of .70 to obtain higher allowable currents. Interpolation would have given 4.0, 29.7, and 157 amperes for our example.

IX.   ACCURACY OF TABLES

The tables, like the charts of reference 1, have been prepared to give cable sizes which may at most be one size greater than actually required by the thermal conditions. When the cables are given, the currents predicted by the table may fall 20 percent below actual allowable currents for the worst conditions.

The largest source of error is due to the fact that the PD values for all possible bundles lie within a narrow band rather than on a single line as assumed here. Two smaller errors are introduced by the fact that the current curves are represented by a simple power function of the cross-section area and by the assumption that all conductors are at the same temperature.

Table 2 is based on an R curve for AN-18 cables. It can be anticipated that if Table 2 is applied to cable sizes smaller than AN-18 the predicted currents will not be conservative. For the case of 100 AN-22 cables, it gives an allowable current of 2.8 amperes per cable. Actually 2.8 amperes would produce a maximum temperature rise of about 54° instead of 40° assumed by Table 2.

Tables 1 and 2 were applied to four bundles and the results are shown in Tables 3 and 4. In Table 3, the currents are given and the predicted cable sizes, as well as the actual cable sizes, are listed. In Table 4, the cables are given, and the currents predicted by the table are compared with measured currents.

X.   CURRENT-RATING TABLES FOR VARIOUS CONDITIONS

Tables may be prepared for a wide variety of conditions affecting the individual cable properties, bundle construction and environment. Section VI of reference 1 shows briefly how many factors affect the cable-rating charts: conductor and insulation dimensions and materials, ambient air and allowable conductor temperatures, altitude, bundle conduit, troughs, and jackets. The same discussion applies to the tables.

It is evident that type A tables are affected by changes in the individual conductor resistance and cable cross-section area. Type B tables are affected by any factor which modifies the flow of heat within and from the bundle.

One illustration will be mentioned to show how the tables may be adapted to actual installation practice. Suppose that both copper (MIL-W-5086) and aluminum cables (MIL-W-7072) are grouped together in a bundle, and let it be assumed that the limiting temperature is the same for both kinds of cable. How would the cable sizes be selected for such a bundle? One set of tables would be needed for the copper and one set for the aluminum cables. NA values for the copper and aluminum cables would be selected from their respective type A tables, and the TNA would be found as usual by addition. The copper and aluminum cable sizes would then be selected from their respective type B tables for the same TNA value.

XI. A COMPARISON BETWEEN CURRENT RATINGS GIVEN BY THE PROPOSED TABLES AND BY MIL-W-5088A

It has not been possible in the past to evaluate the current ratings of bundled cables as given by MIL-W-5088A. The proposed tables (as well as the charts of reference 1) make it possible to obtain a quantitative estimate of the validity of existing ratings. Table 5[+] has been compiled to compare the rating given by the tables and by MIL-W-5088A for three cable sizes. Thus, it shows us the ratings for an AN-18 cable as a constituent of six possible bundles. The cable sizes loaded simultaneously, other than AN-18, in these six bundles have been chosen to yield either maximum or minimum current values for the AN-18. A total of 3, 6, or 9 cables as the maximum number loaded simultaneously is arbitrary. The number of cables loaded simultaneously constitute only 20 percent of the cables physically bound together in each case. Table 5 shows that ratings given by MIL-W-5088A may seriously overload or underload the cables.

CONCLUSIONS

1. While the selection of cables for use in aircraft according to installation specifications MIL-W-5088 and MIL-W-5088A has the virtue of simplicity, the possibilities of serious underloading or overloading, suggested by Table 5, make it important to consider ratings based on sound thermal assumptions.

2. In the past, serious penalties may have been avoided because most bundles contained few cables, thus tending to make MIL-W-5088 ratings conservative. On the other hand, where bundles contained many cables, the line voltage drop requirement for low voltage systems served indirectly to prevent overloading.

3. The use of larger bundles and of higher voltage systems in aircraft increases appreciably the calculated risk in employing MIL-W-5088A ratings.

[+]Table 5 was prepared jointly by Mr. D. H. Scott and the author.

4. The method of rating and selecting cable proposed in this report will result in the lowest cable weight consistent with the safety of the aircraft.

5. It is recognized that the application of the proposed tables will require some changes in bundle design and installation on the part of the airframe manufacturer. It would be desirable, therefore, to accumulate some experience in their use before their final form for incorporation into the cable rating specification is recommended.

RECOMMENDATIONS

1. It is recommended that steps be taken to place the current rating of aircraft cable on a sound thermal basis as provided in the method proposed in this report.

2. To this end, it is recommended that experience in the use of the proposed cable-selection and -rating tables be obtained by three airframe manufacturers. It is suggested further that one plane of each of the following types be considered for the trial application: an interceptor, a medium bomber, and a transport.

REFERENCE

1. NRL Report 4142, Current and Temperature Rise in Aircraft Cables, Part III - Continuous Current of Cables in Bundles Composed of One or More Cable Sizes, 24 April 1953.

APPENDIX

The fact that all possible nominal bundle areas (TNA) for a given set of currents lie on the same current line is shown as follows. The proof given here is for the case of a bundle having "f" loads of I_1 amperes each and "g" loads of I_2 amperes each which flow simultaneously. The selection of a bundle having only two values of current is made for brevity and does not restrict the generality of the proof.

Let $(PD)_1$ be the first arbitrarily assumed value of PD. Then for current I_1, a nominal cable area, a_1, is obtained from equation (5).

$$a_1 = \left(\frac{R_o}{(PD)_1 a_o^{1+m}} \right)^{-1/m} I_1^{-2/m} \tag{11}$$

For current I_2 and $(PD)_1$, the nominal cable area is

$$a_2 = \left(\frac{R_o}{(PD)_1 a_o^{1+m}} \right)^{-1/m} I_2^{-2/m} \tag{12}$$

Since there are f loads of I_1 and g loads of I_2 we have, on adding, a total nominal area a_3.

$$a_3 = fa_1 + ga_2 = \left(\frac{R_o}{(PD)_1 a_o^{1+m}} \right)^{-1/m} (fI_1^{-2/m} + gI_2^{-2/m}) \tag{13}$$

This TNA, a_3, and PD_1 lie on a current line corresponding to a current I_3 which is simply

$$I_3^{-2/m} = fI_1^{-2/m} + gI_2^{-2/m} \tag{14}$$

as may be seen by comparing equations (11) or (12) and (13).

Let us repeat the process of finding a TNA assuming a different value of PD, namely, $(PD)_2$. The nominal cable area, b_1, for I_1 will be given by

$$b_1 = \left(\frac{R_o}{(PD)_2 a_o^{1+m}} \right)^{-1/m} I_1^{-2/m} \tag{15}$$

Similarly, the area b_2 corresponding to I_2 and $(PD)_2$ is

$$b_2 = \left(\frac{R_o}{(PD)_2 a_o^{1+m}} \right)^{-1/m} I_2^{-2/m} \tag{16}$$

The corresponding TNA for the total f+g loads is

$$b_3 = fb_1 + gb_2 = \left(\frac{R_o}{(PD)_2 a_o^{1+m}} \right)^{-1/m} (fI_1^{-2/m} + gI_2^{-2/m}) \tag{17}$$

Comparing (13) and (17), we see that the two points with coordinates $(fa_1 + ga_2)$, $(PD)_1$ and $(fb_1 + gb_2)$, $(PD)_2$ lie on the same current line.

TABLE 1

EXAMPLE OF PROPOSED NRL CABLE-SELECTION
AND -RATING TABLE FOR AIRCRAFT CABLES

Applicable to MIL-W-5086 Cables for Conditions
Listed on Page 8

AMP	NA	AMP	NA	AMP	NA
1	.0072	50	.213	200	.712
2	.0132	55	.232	210	.746
3	.0188	60	.249	220	.774
4	.0240	65	.268	230	.804
5	.0292	70	.285	240	.832
6	.0342	75	.303	250	.861
7	.0390	80	.320	260	.892
8	.438	85	.336	270	.922
9	.0485	90	.354	280	.952
10	.0532	95	.372	290	.983
11	.0577	100	.389	300	1.01
12	.0622	105	.404	320	1.07
13	.0666	110	.422	340	1.12
14	.0712	115	.438	360	1.18
15	.0756	120	.458	380	1.23
16	.0798	125	.472	400	1.29
17	.0840	130	.487	420	1.35
18	.0880	135	.503	440	1.40
19	.0923	140	.520	460	1.46
20	.0963	145	.538	480	1.52
22	.105	150	.554	500	1.57
24	.113	155	.570	520	1.62
26	.121	160	.586	540	1.68
28	.129	165	.602	560	1.73
30	.137	170	.619	580	1.78
32	.145	175	.634	600	1.83
34	.153	180	.651	650	1.97
36	.161	185	.666	700	2.10
38	.168	190	.681	750	2.23
40	.176	195	.697	800	2.35
42	.184	200	.712	850	2.48
44	.191			900	2.60
46	.199			950	2.74
48	.207			1000	2.87
50	.213				

TABLE 2

EXAMPLE OF PROPOSED NRL CABLE-SELECTION AND -RATING TABLE FOR AIRCRAFT CABLES

Applicable to MIL-W-5086 Cables for Conditions Listed on Page 8

TNA	Cable Size 22	20	18	16	14	12	10	8	6	4	2	1	1/0	2/0	AA
Cable Area	.00567	.00639	.00844	.01075	.01255	.01754	.0284	.0467	.0651	.0922	.1385	.1698	.1976	.259	
.08	11.4	13.1	18.1												.0076
.1	10.7	12.1	16.8	22.1											.0103
.2	8.2	9.4	13.0	17.1	20.5	30.2	52.8								.027
.3	6.8	7.8	10.7	14.2	16.9	24.9	43.5	77.1							.047
.4	5.9	6.8	9.4	12.4	14.8	21.8	38.2	67.6	99.1	148					.070
.5	5.1	6.1	8.4	11.1	13.3	19.6	34.2	60.6	89.0	133	209				.095
.6	4.9	5.6	7.7	10.2	12.2	18.0	31.4	55.6	81.6	122	191				.122
.7	4.5	5.2	7.2	9.5	11.4	16.7	29.2	51.7	75.9	114	178	230			.154
.8	4.2	4.8	6.7	8.8	10.5	15.5	27.1	47.9	70.3	105	165	213	254		.186
.9	3.9	4.5	6.2	8.3	9.9	14.5	25.4	45.0	66.0	98.7	155	200	238	327	.218
1.0	3.7	4.3	5.9	7.8	9.4	13.8	24.1	42.7	62.6	93.6	147	189	226	310	.255
1.2	3.4	3.9	5.4	7.1	8.5	12.5	21.9	38.8	56.9	85.2	134	172	205	282	.334
1.4	3.2	3.6	5.0	6.6	7.9	11.6	20.3	35.9	52.7	78.8	124	160	190	261	.417
1.6	2.9	3.4	4.7	6.1	7.4	10.8	18.9	33.5	49.1	73.5	115	149	177	243	.51
1.8	2.8	3.2	4.4	5.8	6.9	10.2	17.8	31.4	46.1	69.0	108	140	166	228	.60
2.0	2.6	3.0	4.1	5.5	6.5	9.6	16.8	29.8	42.7	65.4	103	132	158	216	.70
2.3	2.4	2.8	3.8	5.1	6.1	8.9	15.6	27.7	40.6	60.7	95.2	123	147	201	.86
2.6	2.3	2.6	3.6	4.8	5.7	8.4	14.7	26.1	38.2	57.2	89.7	116	138	189	1.02
2.9	2.2	2.5	3.4	4.5	5.4	7.9	13.9	24.5	36.0	53.8	84.4	109	130	178	1.20
3.2	2.0	2.3	3.2	4.3	5.1	7.5	13.1	23.2	34.1	51.0	80.0	103	123	169	1.38
3.6	1.9	2.2	3.0	4.0	4.8	7.1	12.4	21.9	32.1	48.0	75.3	97.2	116	159	1.64
4.0	1.8	2.1	2.9	3.8	4.6	6.7	11.7	20.8	30.5	45.6	71.7	92.3	110	151	1.92
4.4	1.7	2.0	2.7	3.6	4.3	6.4	11.1	19.7	28.8	43.1	67.6	87.3	104	143	2.20
4.8	1.7	1.9	2.6	3.5	4.1	6.1	10.7	18.9	27.7	41.4	64.9	83.7	99.8	137	2.50
5.2	1.6	1.8	2.5	3.3	4.0	5.9	10.2	18.1	26.6	39.8	62.4	80.5	96.0	132	2.80

TABLE 3

PREDICTED VERSUS MEASURED CABLE SIZES

Bundle	No. of Loads	Amp. Per Load	NA Per Load		TNA	Cable Sizes	
						Predicted	Measured
I	1	-198	.706	.706		2/0	1/0
	18	- 5.25	.0305	.549		18	18
				1.255	1.25		
II	7	- 5.5	.0317	.2219		16	18
	6	- 40.5	.178	1.068		6	8
				1.2899	1.29		
III	6	140	.520	3.12		2/0	1/0
	19	3.75	.0227	.431		16	18
				3.551	3.55		
IV	2	102.5	.397	.794		2	4
	6	11.5	.0600	.360		12	14
				1.054	1.05		

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TABLE 4

PREDICTED VERSUS MEASURED CURRENTS

Bundle	No. of Cables	Cable Size	Cross Section Area per Cable IN^2		AA	Current Amperes	
						Predicted	Measured
I	1	1/0	.1976	.1976		202	198
	18	18	.00844	.1519		5.3	5.25
				.3495	.349		
II	7	18	.00844	.0591		5.4	5.5
	6	8	.0467	.2800		38.7	40.5
				.3391	.339		
III	6	1/0	.1976	1.186		126	140
	19	18	.00844	.1602		3.2	3.75
				1.346	1.346		
IV	2	4	.0922	.1844		93.1	102.5
	6	14	.01255	.0753		9.3	11.5
				.2597	.2597		

TABLE 5

COMPARISON BETWEEN CURRENT RATINGS
GIVEN BY MIL-W-5088A AND TABLES 1 & 2

Nominal AN Cable Size	MIL-W-5088A Bundle Rating of Nominal Cable (Amperes)	Bundle Composition			Allowable current rating of nominal AN cable when loaded simultaneously with the cables shown. Current values based on Tables 1 and 2.
		Total No. of Cables in Bundle; i.e., Loaded and Dummy Cables	No. of Cables Loaded Simultaneously	Loaded Cable Sizes 1 Nominal Cable and	
18	10	15	3	2AN-2	5.7
		15	3	2AN-22	14.6
		30	6	5AN-2	4.1
		30	6	5AN-22	11.8
		45	9	8AN-2	3.5
		45	9	8AN-22	10.3
8	46	15	3	2AN-2	39
		15	3	2AN-22	72
		30	6	5AN-2	29
		30	6	5AN-22	66
		45	9	8AN-2	25
		45	9	8AN-22	61
2	100	15	3	2AN-2	125
		15	3	2AN-22	179
		30	6	5AN-2	95
		30	6	5AN-22	173
		45	9	8AN-2	83
		45	9	8AN-22	166

POWER DISSIPATION DENSITY VERSUS CABLE

CROSS-SECTION AREA

FOR TYPICAL MIL.—W-5086

CROSS-SECTION AREA OF INSULATION
AND CONDUCTOR

10^{-2} 10^{-1}

10^{-4} 10^{-3} 10^{-2} 10^{-1}

$\frac{1}{0}$

4

8

AN-CABLE SIZES

12

16

18

20

POWER DISSIPATION DENSITY (PD) - WATT INCH^{-3}

$\left(\dfrac{I^2 R_n}{a_n} \text{ VERSUS } a_n \text{ WHERE} - \begin{array}{l} I = \text{ONE AMPERE.} \\ R_n = \text{RESISTANCE PER INCH AT } 65°\text{C.} \\ a_n = \text{CROSS-SECTION AREA OF} \\ \quad \text{INSULATION \& CONDUCTOR.} \end{array} \right)$
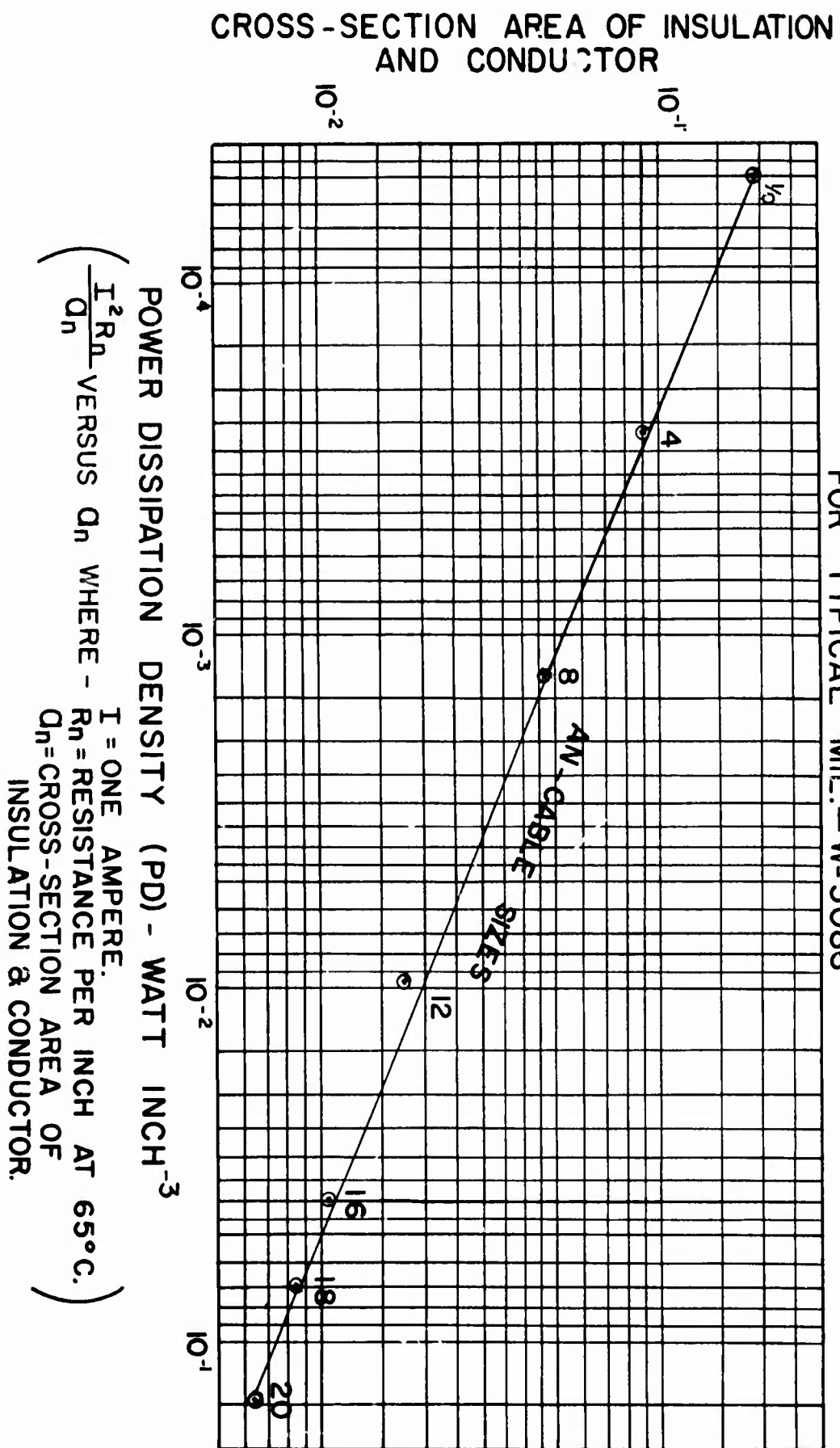
FIGURE. 2

AVERAGE (PD) PER INCH LENGTH OF BUNDLES OF
AN-18 CABLES VERSUS CROSS-SECTION AREA.

POWER DISSIPATION DENSITY (PD)
WATT INCH⁻³

CROSS-SECTION AREA OF INSULATION AND CONDUCTOR - INCHES²
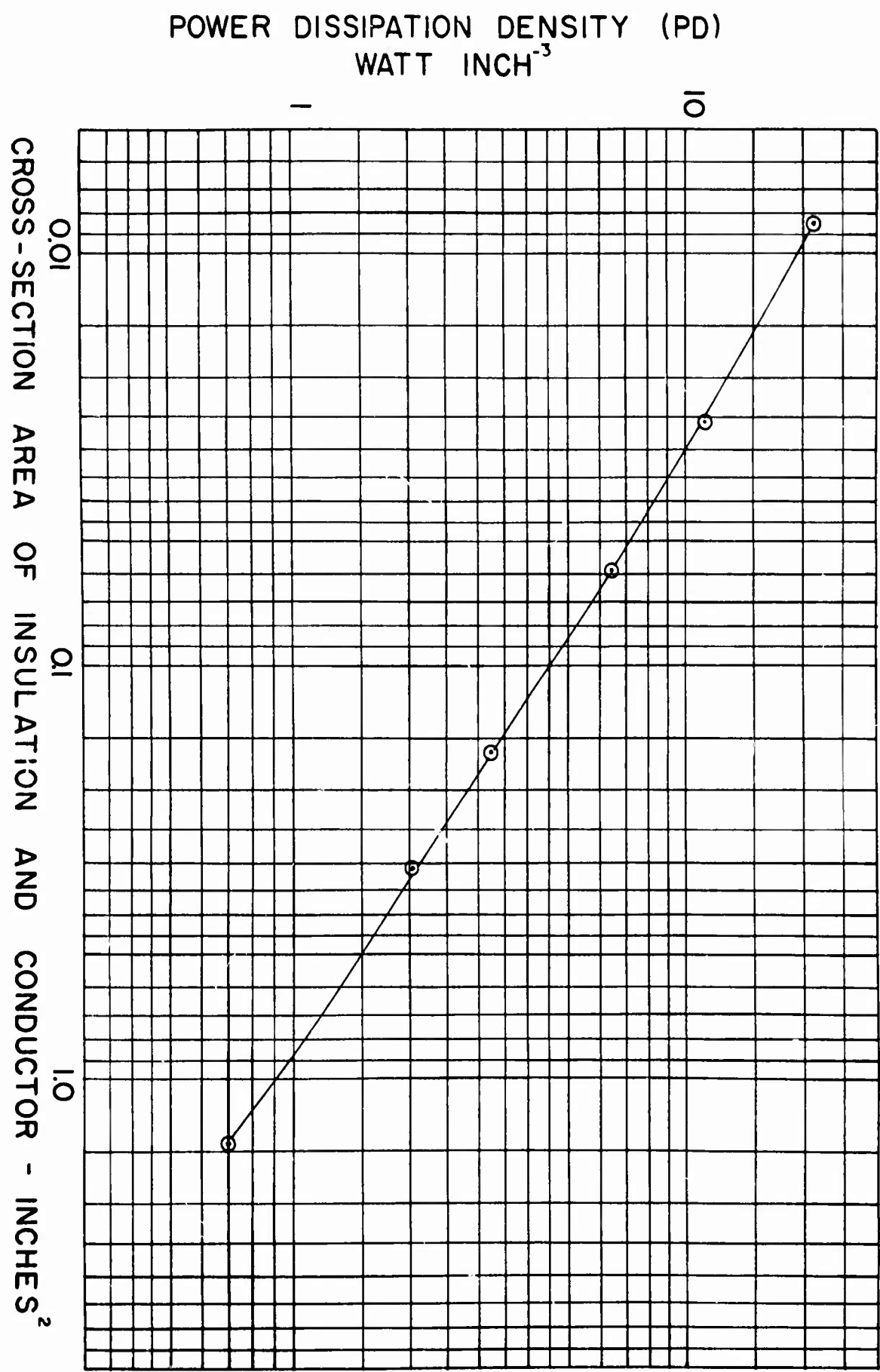
(TEMPERATURE OF HOTTEST CONDUCTOR=65°C, AMBIENT AIR TEMP.=25°C, AT SEA LEVEL)
FIGURE. I